PART C — (1 × 15 = 15 marks)

16. (a) A uniform sheathing of plastic insulation (k = 0.18 W/m.°C) is applied to an electric cable of 8 mm diameter. The convective heat transfer coefficient on the surface of bare cable as well as insulated cable was estimated as 12.5 W/(m^2°C) and a surface temperature of 45°C was observed when the cable was directly exposed to ambient air 20°C. Determine :

(i) the thickness of insulation to keep the wire as cool as possible and

(ii) the surface temperature of insulated cable if the intensity of current flowing through the conductor remains unchanged.

Or

(b) Air is to be heated by passing it over a bank of 3 m long tubes inside which steam is condensing at 100°C. Air approaches the tube bank in the normal direction at 20°C and 1 atm with a mean velocity of 5.2 m/s. The outer diameter of the tubes is 1.6 cm, and the tubes are arranged staggered with longitudinal and transverse pitches of 4 cm. There are 20 rows in the flow direction with 10 tubes in each row. Determine the rate of heat transfer and the rate of condensation of steam inside the tubes.

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 53309

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Fifth/Sixth/Seventh Semester

Mechanical Engineering

ME 6502 — HEAT AND MASS TRANSFER

(Common to Mechanical Engineering (Sandwich)/Mechanical and Automation Engineering)

(Regulation 2013)

(PTME 6502 – Heat and Mass Transfer for B.E. (Part-Time) Mechanical Engineering – Fourth Semester – Regulation 2014)

Time : Three hours Maximum : 100 marks

State clearly any assumption made with justification.

Use of Standard Steam Table and HMT data book is allowed.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is thermal time constant?

2. Consider two finned surfaces that are identical except that the fins on the first surface are formed by casting or extrusion whereas they are attached to the second surface afterwards by welding or tight fitting.

   For which case do you think the fins will provide greater enhancement in heat transfer? Why?

3. What is the usefulness of Rayleigh number in free convection?

4. For a heated horizontal plate in quiescent air, do you expect heat transfer to be larger for the top or bottom surface? Why?

5. Briefly explain why in steam condensers the LMTD is independent of flow arrangement?

6. Consider film condensation on a vertical plate. Will the heat flux be higher at the top or at the bottom of the plate? Why?

7. What is the crossed-strings method?

8. What is thermal radiation and how does it differ from the other forms of electromagnetic radiation?

9. What is mass diffusivity?

10. State the reason for development of concentration boundary layer.

PART B — (5 × 13 = 65 marks)

11. (a) To defrost ice accumulated on the outer surface of a car windshield, warm air is blown over the inner surface of the windshield. Consider windshield thickness is 5 mm and its thermal conductivity is 1.4 W/(m.K). The outside ambient temperature is -10°C and the convection heat transfer coefficient is 200 W/(m².K), while the ambient temperature inside the car is 25°C. Determine the value of the convection heat transfer coefficient for the warm air blowing over the inner surface of the windshield necessary to cause the accumulated ice to begin melting.

Or

(b) An average convective heat transfer coefficient for flow of 90°C air over a flat plate is measured by observing the temperature time history of a 40 mm thick copper slab (ρ = 9000 kg/m³ c = 0.38 kJ/kg°C; K = 370 W/m°C) exposed to 90°C air. In one test run, the initial temperature of the plate was 200°C, and in 4.5 minutes the temperature decreased by 35°C. Find the heat transfer coefficient for this case. Neglect internal thermal resistance.

12. (a) Air at 273 K at 75 m/s flows over a plate having 45 cm length 62 cm wide. The plate is maintained 90°C temperature. Assuming the transition of boundary layer takes place at critical Reynolds number of 5×10^5, find the average values of friction coefficient and heat transfer coefficient for the full length of the plate. Also get energy dissipation from the plate.

Or

(b) A 10 cm diameter sphere is maintained at 120°C. It is enclosed in a 12 cm diameter concentric spherical surface maintained at 100°C. The space between two spheres is filled with air at 200 kPa. Calculate the convective heat transfer rate from inner sphere.

13. (a) A cross flow heat exchanger with both fluids unmixed is used to heat water flowing at a rate of 20 kg/s from 25°C to 75°C using gases available at 300°C to be cooled to 180°C. The overall heat transfer coefficient has a value of 95 W/(m².K). Determine the area required. Also find the gas flow rate. Assume for gas, c_p = 1005 J/(kg-K).

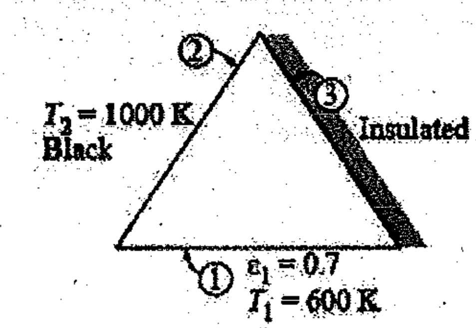
Or

(b) Water is boiled at 120°C in a mechanically polished stainless steel pressure cooker placed on top of a heating unit. If the inner surface of the bottom of the cooker is maintained at a temperature of 128°C, determine the boiling heat transfer coefficient.

14. (a) The temperature of the filament of an incandescent lightbulb is 2500 K. Assuming the filament to be a blackbody, determine the fraction of the radiant energy emitted by the filament that falls in the visible range. Also determine the wavelength at which the emission of radiation from the filament peaks.

Or

(b) A furnace is shaped like a long equilateral triangular duct, as shown in Figure. The width of each side is 1 m. The base surface has an emissivity of 0.7 and is maintained at a uniform temperature of 600 K. The heated left-side surface closely approximates a blackbody at 1000 K. The right-side surface is well insulated. Determine the rate at which heat must be supplied to the heated side externally per unit length of the duct in order to maintain these operating conditions.



15. (a) A vessel contains a binary mixture of O_2 and N_2 with partial pressures in the ratio 0.21 and 0.79 at 288 K. The total pressure of the mixture is 1.1 bar. Find,

(i) molar concentrations

(ii) mass densities

(iii) mass fractions and

(iv) molar fractions of each species.

Or

(b) Air at 20°C (ρ = 1.205 kg/m³ ϑ = 15.06×10^{-6} m²/s; D = 4.166×10^{-5} m²/s) flows over a tray (length = 320 mm, width = 420 mm) full of water with a velocity of 2.8 m/s. The total pressure of moving air is 1 atm and the partial pressure of water present in the air is 0.0068 bar. If the temperature on the water surface is 15°C, calculate the evaporation rate of water.